



Stakeholder interaction within research consortia on emerging technologies: Learning how and what?

Anneloes Roelofsen*, Wouter P.C. Boon, Roy R. Kloet, Jacqueline E.W. Broerse

Athena Institute for Research on Innovation and Communication in Health and Life Sciences, Vrije Universiteit Amsterdam, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands

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ABSTRACT

One of the challenges for public–private R&D collaborations in emerging scientific fields is to actively include the demand side. Insight in how to facilitate learning between stakeholders is, however, lacking. In this paper we present an approach to facilitate and analyse learning processes in multi-stakeholder interactions within public–private research consortia working on new science and technologies. The learning processes that took place during dialogue meetings within the framework of the Dutch Ecogenomics Consortium were analysed, including a reflection on the actual effects. The results show that a carefully structured dialogue method facilitates learning between researchers, users and policy-related participants, and that this learning to some extent is anchored within the Ecogenomics Consortium. At the same time, the results point to the challenges of translating learning into action.

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1. Introduction

Starting from the idea that innovation is more productive as a cooperative activity, research and development projects often take collaborative forms, such as joint ventures, R&D alliances, R&D consortia, strategic technology partnerships, and open innovation networks (Aldrich and Sasaki, 1995; Chesbrough, 2003; Link et al., 2002; Mathews, 2002). There is one specific form of public–private collaboration that has increasingly attracted attention in public research policy: large-scale, multidisciplinary research programmes. These programmes comprise both research institutes and companies, revolve around broad, emerging scientific fields, such as nanotechnology or genomics, and are instigated by the government (Corley et al., 2006; Robinson et al., 2007; Shapira et al., 2001). These fields typically have to deal with a broad network of actors, and require large investments with a high uncertainty of economic return.

Research programmes consisting of stakeholders coming from different disciplinary backgrounds call for intensive and frequent interactions and exchanges between producers and users of knowledge. The importance of these interactions is in line with new technologies being developed following iterative, non-linear processes, in which both demand and supply of knowledge and technology simultaneously play a role (Edler and Georghiou, 2007; Mowery and Rosenberg, 1979; Smits and Boon, 2008; Von Hippel, 1988). These intensive user–producer interactions have several

beneficial impacts, such as overcoming market failures, making use of the creative potential of users, enhancing the efficiency of the innovation process, and taking into account social acceptability of new technologies (Smits and Boon, 2008). These arguments are not restricted to knowledge users but also apply to the involvement of societal stakeholders.

In addition, recent developments in emerging science and technology fields have shown the importance of addressing societal aspects of new technologies. As a result, publicly funded research programmes, like the Human Genome Project, have incorporated research into the ethical, legal and societal aspects (Lambright, 2002). Initiatives such as these aim to address these aspects in an early phase of development, and relate to moral and political responsibilities in order to minimise the potentially disruptive impact of emerging technologies (Fisher, 2005). These programmes thus call for the involvement of societal stakeholders in the decision-making process, or at least being susceptible to their opinions.

A variety of studies concentrate on the involvement of users in research and development (Lundvall, 1992; Oudshoorn and Pinch, 2003; Von Hippel, 1988). However, although there are recent examples in nanotechnology (Guston and Sarewitz, 2002; Merkerk, 2007), there are few attempts to actively include the demand side in R&D collaborations, particularly in the case of emerging technologies. User involvement initiatives within these collaborations usually concern sounding boards, utilisation panels, and consultations. These activities aim to provide input from a user perspective, but are not interactive and do not offer end users and other relevant stakeholders the opportunity to co-decide.

* Corresponding author. Tel.: +31 20 5986656; fax: +31 20 5987027.
E-mail address: anneloes.roelofsen@falw.vu.nl (A. Roelofsen).

Lyall et al. (2004) reflect on a combination of qualitative and quantitative methodologies for assessing end-user relevance of publicly funded research. They stress the challenge of embedding end-user evaluation throughout the research process and to let it “guide the ongoing development of institutional research quality” (p. 86). Furthermore, Lyall et al. (2004) highlight a crucial point of attention for approaches that actively include the user perspective: the flexibility needed at the same time runs the risk of being criticised “on the grounds of consistency, reproducibility and robustness” (p. 87). These observations indicate a need to develop theoretical understanding and sound methodologies for shaping user–producer interactions. Also within the field of science and technologies studies (STS) there is a growing recognition that explicating theoretical assumptions and methodologies is crucial in empirical analysis of science and technology development (Hackett et al., 2007).

Focussing on the methodological aspects of user–producer interactions, some important aspects need to be addressed. Klerkx and Leeuwis (2008) point to the limitations of current research systems in which user demands are easily overruled as they are being considered as ‘inadequate’ by researchers. They stress a need for participatory methods that create room for “a careful analysis of the position of the different actors, and a synchronisation of the different norms, values and incentive systems in a joint and sustained process of demand articulation” (Klerkx and Leeuwis, 2008, p. 469). Shaping such user–producer interactions involves learning processes (Hyysalo, 2009; Lundvall et al., 2002; Williams et al., 2005). However, Hyysalo (2009) points out that these learning processes largely remain black boxes as insight in micro-level learning is currently lacking. Empirical case studies thus need to focus on transparency about the goals (what are the aims of the user–producer interactions?), methodology (how are the user–producer interactions shaped?), and analysis of the results (what is learned?).

This paper reflects on an empirical case study in which an approach for stakeholder involvement was designed and implemented in the context of a public–private research consortium in the emerging scientific field of ecological genomics: the Dutch Ecogenomics Consortium. Researchers from both public and private organisations within this R&D consortium had a central role in reflecting on their work and the relation with societal aspects, by articulating future visions, and in interacting with a broad range of stakeholders, explicitly including potential technology users and policymakers, during so-called interactive dialogue meetings. These multi-stakeholder dialogue meetings aimed to foster mutually beneficial learning between participants about these future visions as well as the norms, values and incentive systems underlying them. As such, these settings provide an occasion wherein the potential micro-level processes of learning can be empirically analysed. The aim of this paper is twofold: (1) explicating a methodological approach to organising user–producer interaction within the context of large public–private research collaborations, and (2) analyse to what extent learning is facilitated in the context of these collaborations.

By explicating the methodological approach we aim to address the current lack of attention for multi-stakeholder involvement in large scale research collaborations, and offer practitioners building blocks for designing multi-stakeholder dialogues. Furthermore, we try to unravel the learning ‘black box’ by analysing the learning that took place during the dialogue meetings, and the extent to which this learning is anchored in the actions of the stakeholders involved. This improves our understanding of whether, and how, a multi-stakeholder dialogue is helpful in taking into account multiple perspectives in innovation processes. At the same time, the societal relevance of this approach lies in assisting participants in high-tech R&D consortia to incorporate ideas about desir-

able future developments from different disciplines and societal backgrounds.

In the next section we reflect on the dialogue methodology, characterise the type of dialogue used within the Ecogenomics Consortium, and reflect on different types of learning in relation to stakeholder participation described in literature. We subsequently present the organisational context and structure of the Dutch Ecogenomics Consortium, and the specific approach we developed for stakeholder participation in emerging technologies (Roelofsens et al., 2008). We then present the methodological design of the dialogue meetings and propose an analytical framework to evaluate learning processes in dialogues. We apply this analytical framework to the dialogue meetings, reflect on the results, and relate the results of the meetings to the follow-up activities that were initiated.

2. Stakeholder involvement and learning

Under the umbrella of ‘dialogues’, many different types of stakeholder participation and participatory methodologies for organising science–society interaction have been proposed (Davies et al., 2009). Below, the characteristics of dialogues are clarified by briefly reflecting on stakeholder participation and the difference between dialogues aiming for consensus or for deliberation. Furthermore, we investigate different types of learning in relation to stakeholder participation described in literature.

2.1. Stakeholder participation

In this paper the focus lies on stakeholder participation in science, which differs from stakeholder participation in policy-making (Davies et al., 2009; Kerkhof, 2004). Stakeholder participation in science takes place on the sidelines of the governmental policy process, has a more long-term focus and explores long-term developments in a certain problem arena (Kerkhof, 2004). Welp et al. (2006) refer to this type of stakeholder participation as ‘science-based stakeholder dialogues’, which can be defined as “a structured communicative process of linking scientists with selected actors that are relevant for the research problem at hand”. The importance of broadening the debate is emphasised using both substantial (improving decision-making quality), instrumental (speed up the acceptance of ideas) and normative arguments (the democratic quality of decision-making in innovation processes) (Caron-Flinterman et al., 2007; Fiorino, 1990; Smits and Boon, 2008).

2.2. Consensus or deliberation

Stakeholder dialogues conducted within the policy arena often focus on consensus-building by developing policy recommendations that meet the needs of all the stakeholders involved (Kerkhof, 2006). Intuitively, discussing aspects of new and emerging technologies also asks for a convergence of problem definitions, ideas, opinions, and framings; especially when these technologies are (potentially) controversial. The harmonisation or orchestration of demands and framings is often the objective of prospective meetings regarding new technologies. In the context of interactive technology assessment, Grin et al. (1997 p. 43) call these processes a “joint construction: a synthesis between the participants’ different beliefs”.

However, it is questionable whether consensus on complex multi-faceted issues surrounding science and technology developments is achievable or desirable (Irwin and Michael, 2003; Irwin, 2006). For example, putting too much emphasis on consensus can make certain groups hesitant to participate (Hagendijk and Irwin, 2006). Moreover, dissent on certain issues is at least as impor-

tant, as it reveals different ways of framing issues and interesting areas where further research is needed (Welp et al., 2006). Particularly regarding emerging technologies, which are in their early phases of development, broadening and enriching of debates is appreciated (Nahuis, 2007; Van Merkerk, 2007). This involves an increase in the range of actors involved and topics that are put on the agenda, and avoids exclusion of stakeholders and potentially creative ideas. In that case, the focus is more on deliberation than on consensus-building. Deliberation is characterised by a process of dialogue and argumentation which facilitates stakeholders to exchange viewpoints and gain in-depth understanding of their own and each others' positions and underlying assumptions (Kerkhof and Wieczorek, 2005).

2.3. Learning processes

The learning that takes place between users and producers in innovation has received much attention both within the fields of science, technology and society studies and innovation studies. Prominent examples are work of Lundvall and Johnston on 'learning by doing, using and interacting' (DUI) (Lundvall, 1988; Lundvall and Vinding, 2005), and "social learning in technological innovation" (SLTI) by Williams et al. (2005). In analysing the way these approaches treat learning, Hyysalo (2009) points out that they treat learning as a prerequisite for user–producer interactions and focus on macro-level and long-term outcomes of these learning processes. However, the process of learning itself remains underexposed: 'there is [...] a lack of concepts for discussing micro-level learning processes and there has been little reporting on research designs concerning ways to study them' (Hyysalo, 2009 p. 733).

Building on findings in cognitive psychology and pedagogy, learning can be defined as absorbing, assimilating and (re)constructing new knowledge (Berger and Luckmann, 1967). Learning is often conceived as a process consisting of several stages, such as understanding the problem; devising a plan; executing the plan; reflection (Polya, 1957) or "learning dynamics" consisting of searching, evaluating, and reconsidering the technology (Hyysalo, 2010). Several scholars in organisational studies found these processes applicable on the level of organisations (Cyert and March, 1963; Hedberg, 1981; Huber, 1991; Kolb, 1976; Pawlowsky, 2000), groups, and specific settings in which two different kinds of stakeholders meet (Hasu and Engestrom, 2000; Hyysalo, 2006). Although other learning dynamics have been proposed, e.g. domestication that focuses on the appropriation phase of innovation processes (Lie and Sorensen, 1996), here we just use the stages to indicate our emphasis on the first two learning stages: understanding the problem, and devising a plan. Ideally, the subsequent stages (executing the plan and reflection) are initiated by participants as follow-up on the dialogues.

With regard to the way learning processes are analysed in this paper, two aspects need further specification. Firstly, throughout the different stages, we assess learning using the concepts first-order (or single loop) and second-order (or double loop) learning as developed by Argyris and Schön (1978). Schön (1983) looked at activities of professionals, especially in unique and complex cases of high uncertainty and instability. He concluded that they shifted back and forth between problem definitions and solutions, using professional codes of conduct, earlier experiences and other generic notions as guidance. He called these assumptions that steered professional's behaviour 'frames of meaning'. Professionals learn on two aspects: on the substantive level of (proposed) actions and outcomes, ideas and problem definitions (first-order); and on the reflexive level of assumptions underlying these ideas and problem definitions (second-order). These first- and second-order learning concepts have been frequently applied in policy sciences (Fischer, 1980; Sabatier, 1987), and in technology and innovation stud-

ies (Grin and Van De Graaf, 1996; Hoogma, 2000; Kerkhof and Wieczorek, 2005). Secondly, learning is situated in the context of multi-level games in which various stakeholders are involved. Learning in groups creates the possibility of generating a diverse set of ideas as well as getting acquainted with other actors' underlying norms and values (Isaacs, 1993; Levine and Moreland, 2004).

The analytical framework to analyse first- and second-order learning is further elaborated in Section 4.2. The next sections illuminate the organisational context and methodology of the science-based stakeholder dialogues.

3. The Ecogenomics Consortium and stakeholder participation

The Ecogenomics Consortium was established in 2003 and co-funded by the Dutch government, with the important precondition that players from public research and industry are brought together. As a result, the Ecogenomics Consortium was organised as a large-scale public–private R&D consortium in which universities, national research institutes and companies with a focus on R&D participate. Its aim is to pursue genomics science and technologies for sustainable use of soil ecosystems for agriculture and other anthropogenic purposes¹ and it comprises research across the disciplines of ecology, microbiology, soil sciences, environmental sciences, biotechnology and bioinformatics.

Within the Ecogenomics Consortium there is a strong focus on societal needs, which is stimulated by the funding structure of the programme. The research programme was selected on the basis of its scientific excellence and its potential relevance for the Dutch economy and society as a whole. The Ecogenomics Consortium includes research projects on interdisciplinary collaboration and societal aspects of ecogenomics. The main assumption underlying these projects is that interdisciplinary collaboration and involvement of relevant stakeholders increases the scientific and societal value of research, results in the development of products that effectively address complex societal problems, and offers opportunities for initiating follow-up research projects. An explicit choice was made to investigate the societal implications in an interactive way, rather than on ex-post monitoring. The research aimed to identify and integrate a broad range of societal perspectives on (un)desirable future directions for ecogenomics. The researchers remained impartial to the actual outcomes of these processes. Also the extent to which the processes resulted into consensus or convergence of topics was not predefined as a desired outcome, as was explained in Section 2.2.

In current R&D practice, however, the involvement of non-scientific parties is often placed at later stages of technology developments, and restricted to questions around the utilisation of new technologies (e.g. the risks involved). As a result, underlying assumptions and fundamental questions about ownership, benefits and purposes of new science and technology are not under discussion (Chilvers, 2008; Wynne, 1995). These issues are left to the formal and informal controls within science, which remain dislocated from the public (Mayer, 2003). Several authors argue that innovation processes should be seen as interactive design processes in which a dialogue between end users, knowledge producers and other relevant stakeholders is beneficial (Bunders et al., 1999; Klerkx and Leeuwis, 2008; Leeuwis, 1999). A prominent example of such an interactive design process is constructive technology assessment (CTA), which strives for better societal embedding of science and technology developments by anticipation on societal aspects already in an early phase (Rip and Misa, 1995; Schot and Rip, 1997). CTA exercises aim for the early inclusion of a broad

¹ www.ecogenomics.nl.

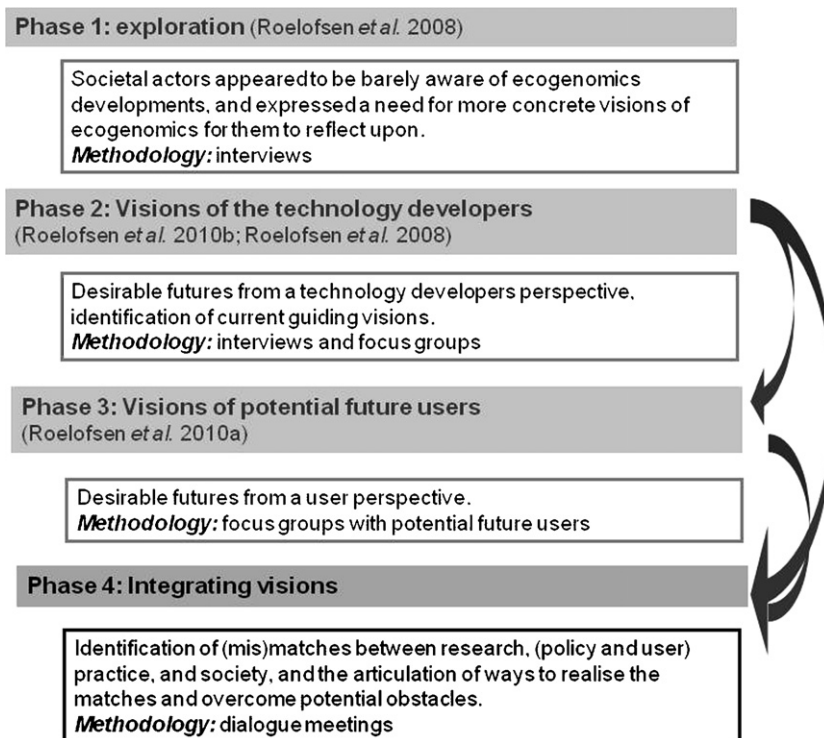


Fig. 1. CTA process on ecogenomics.

range of relevant actors and the articulation of their needs, and are designed to stimulate learning processes (Smits et al., 2010). As such, CTA activities aim to create a shared responsibility for the societal embedding of new science and technology between research institutes, businesses, end users, policy makers, and financial institutions (Merkerk, 2007).

The dialogue meetings that are being presented in this paper form the fourth phase of a CTA process that is being developed and applied within the Ecogenomics Consortium². Fig. 1 shows the subsequent steps in this approach. In the previous phases of this process, researchers of the Ecogenomics Consortium and groups of potential future users already reflected on the future of ecogenomics separately (Roelofsen et al., 2008; Roelofsen et al., 2010a,b).

An important characteristic of this approach is the continuous involvement of the consortium's researchers. This 'reflexive engagement' of scientists and engineers has been recognised as crucial to create commitment for the process and its results, in order to generate a durable impact on R&D processes (Fisher et al., 2006). Illustrative in this respect is that the directors of the Ecogenomics Consortium themselves initiated the dialogues on the topics 'Ecogenomics in agriculture and nature conservation' and 'Ecogenomics and soil pollution'. In these dialogue meetings, besides consortium members, a broad range of stakeholders coming from outside the consortium participated. The participant selection was largely based on the stakeholder network that resulted from the first three phases of the process, in which stakeholders were already interviewed or participated in focus groups. In addition, this network

² In our case we built on the Interactive Learning and Action (ILA) approach. The ILA approach has been developed as a CTA strategy in order to enhance farmer-oriented innovation processes in developing countries (Broerse, 1998; Broerse and Bunders, 2000). More recently this approach has been applied in the context of patient participation in decision-making on health research (Caron-Flinterman et al., 2006). In order to be successfully used in the context of emerging technologies, the ILA approach is integrated with vision assessment (Grin and Grunwald, 2000; Roelofsen et al., 2008).

was broadened through several formal and informal meetings with relevant stakeholders and regular attendance of soil-related meetings by the researchers of this project.

4. The dialogue meetings on ecogenomics

The dialogue meetings that were organised in the context of the Dutch Ecogenomics Consortium are by definition rather isolated 'spaces' (Edler et al., 2006) or 'arenas' (Benz, 2007), with a focus on deliberation. Within these spaces, first- and second-order learning is stimulated by the methodological design. First, the design of the dialogue meetings is introduced. Subsequently the analytical framework is presented and used to analyse whether and to what extent learning among and between participants occurred.

4.1. Meeting design

In the period February–June 2008 two dialogue meetings were organised, one focused on 'Ecogenomics in agriculture and nature conservation',³ the other on 'Ecogenomics and soil pollution'. Table 1 lists the number and type of participants.

The methodological design of the dialogue meetings was standardised for the two meetings and was semi-structured. Both meetings lasted one day and were led by experienced facilitators who guided the discussions. They had substantive knowledge about ecogenomics and the practices of the participants, but were independent and impartial to the outcomes of the process. The discussions were audio-taped and transcribed for further analysis. The participants consented to these recordings on conditions of anonymity and restricted use for the purpose of this study. Participants were actively involved through short individual and

³ The participants from nature conservation that were invited for the second meeting were not able to attend. As a result, this meeting had a stronger focus on agriculture.

Table 1
Group, type and number of participants.

Main groups	Type of participant	Number of participants	
Dialogue meeting 'Ecogenomics in agriculture and nature conservation'	Ecogenomics researchers	University	3
		Research institute	2
		Company	2
	Users	Applied researcher	3
		Agricultural research and consultancy	8
		Farmer representative	4
	Policy-related	Company	1
		National government	2
		Governmental advisory board	1
		Knowledge transfer institute	1
		National research institute	1
		Total: 28	
Dialogue meeting 'Ecogenomics and soil pollution'	Ecogenomics researchers	University	4
		Research institute	1
		Company	3
	Users	Soil companies	3
		Environmental research and consultancy firm	3
	Policy-related	National government	2
		Governmental advisory board	1
		Standardisation organisation	1
		Knowledge transfer institute	1
			National research institute
		Total: 20	

collective assignments. The outcomes of the individual assignments and group discussions were visualised on large schemes on the wall. The subsequent steps taken during the meetings are presented in **Box 1**. To challenge the participants to think of concrete opportunities for ecogenomics, these steps worked toward the formulation of promising matches between supply and demand, and related quick wins (short-term opportunities and actions).

4.2. Analytical framework

In analysing the results of the meeting, a descriptive approach to the discussions is taken in which divergence and convergence between stakeholders on the ideas, problems, etc., and the assumptions underlying these demands is analysed. In other words, learning among and between participants and the extent to which this led to a jointly constructed position is investigated.

As was introduced in Section 2.3, learning involves both the first-order level, such as ideas, problem definitions, etc., and the second-order level, such as frames of meaning. When analysing learning, four different combinations of agreement and disagreement on first- and second-order level are possible, which relate to four different situations of joint construction of demand, so-called 'construction states' (see Fig. 2) (Boon, 2008). If actors agree on both first-order and second-order elements, the demand is 'identical, complementary, or shared'. At the other end of the spectrum, if actors do not agree on both levels, their demands are 'divergent'. The two states in between encompass one in which actors agree on their underlying assumptions but nevertheless disagree on the first-order demands ('untuned' demands), and a state in which actors have different values, but can still work together on the first-order level ('congruent' demands).

In the analysis of the data, the following three steps were taken:

Step 1: Assess the extent to which different actors agree or disagree with each other on first- and second-order level before the dialogue meetings (ex-ante).

Box 1: Meeting design.

1. Opening presentations

The importance of the meeting, the policy implications of ecogenomics and the results of the earlier phases (focus groups) were presented by the director of the Ecogenomics Consortium, a representative of the government, and the social scientists involved.

2. Presentations demand side (+ assignments supply side)

A diverse selection of four participants from the demand side (e.g. companies, advisory organisations, NGOs) presented their short-term and long-term needs regarding soil information and soil use in their field of work. While listening to the presentations, participants from the supply side (members of the Ecogenomics Consortium) were asked where they saw opportunities for ecogenomics, and write these down on post-its. During a break, large schemes were placed on the wall on which the presentations were listed and summarised. Participants were asked to place their post-its on these schemes.

3. Presentations supply side (+ assignments demand side)

Five participants from the supply side presented their research, and specifically focussed on the practical applications they have in mind. While listening to the presentations, participants from the demand-side were asked to think about opportunities for ecogenomics in practice, and write these down on post-its. They also placed their post-its on schemes during the break.

4. Group discussions about matches between supply and demand

In two or three smaller groups (of app. 10 participants), participants discussed matches between supply and demand using the schemes as input. Aim of the discussion was to identify and explicate chances for ecogenomics in practice. Participants were asked to select not more than 5 matches that they wanted to discuss further.

5. Integration of group discussion results and selection of matches for further discussion

In a plenary session, the results of the different groups were shortly summarised by the facilitators. Together with the participants they discussed the overlap and differences between the group results, and determined a final list of matches for further discussion.

6. Discussions about the matches and identification of 'quick wins' in small groups

The aim of discussing the matches was to understand what it takes to realise the matches. What parties are needed? Who needs to do what? How should it be organised? What are potential pitfalls? During the group discussions, the facilitators walked around to focus discussions where necessary. The groups were asked to visualise the results of their discussion on flap-over sheets.

7. Presentation of the results by each group and closing

At the end of the meeting all groups presented their results and discussed them plenary. Subsequently the meeting was closed by the (co-)director of the Ecogenomics Consortium. Participants were asked to fill in an evaluation form to reflect on the quality and usefulness of the meeting. Some weeks after the meeting, participants received a detailed report and were invited to give feedback on the content of the report.

- What were the positions of the participant groups at the start of the meeting? To this aim, the presentations at the start of the meeting were analysed on first- and second-order elements. The positions of the participant groups are derived by grouping all statements made by individuals in the same group and aggregate them, i.e. analyse the content of the statements and determine the common denominator. If this was not possible,

Table 2
First- and second-order statements.

Type of statement	Characteristics	Example quotes
First-order	Concerning problem definitions, proposed actions and outcomes.	'I expect quick results from testing hypothesis in practice.' 'We cannot yet steer in the direction of a desired function.' 'You need someone to translate to practice.'
Second-order	Concerning assumptions underlying problem definitions and proposed actions, the underlying values.	'It is not scientific to say: this is the norm, above is bad, below is good.' 'Soils need to be placed in a different perspective: from dirty to vital.'

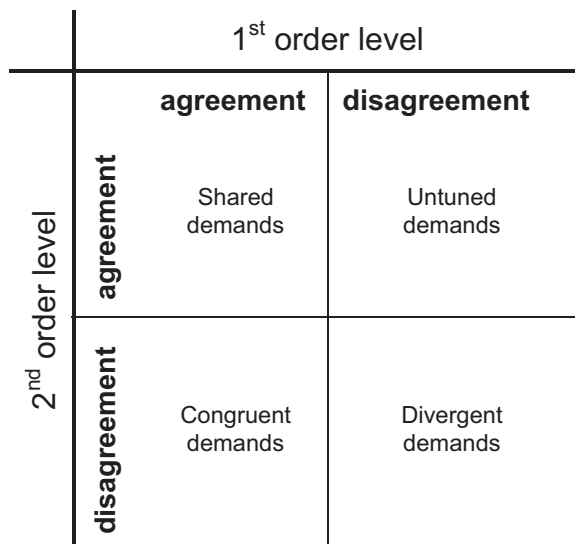


Fig. 2. Four states of demand.

e.g. because two different positions existed within one participant group, this was taken into account while presenting the results. The first- and second-order statements were categorised using the definitions in Table 2. This coding exercise was done by three researchers separately and subsequently compared, thereby ensuring interpreter reliability.

Step 2: Assess the extent to which the ideas and perspectives of the different participants change on both first- and second-order levels (ex durante).

- What were the positions of participant groups during, and directly after the meeting? The transcripts of the dialogue meetings were analysed on statements of participants containing first- and second-order elements in the same way as in Step 1.
- To what extent did the positions of participants change during the interactions in the dialogue meetings? In order to see if learning occurred, we analysed whether shifts in agreement and disagreement took place during the dialogue meetings. The transcripts were analysed on changes in positions of participants in relation to their interaction with other participants, on both first- and second-order elements. Especially the last part of the dialogue meetings provided room for changes on the two learning levels when the participants actively sought for 'matches', 'common grounds' and 'quick wins'.⁴ Shifts in positions were analysed by structurally comparing the aggregated (over the distinct participant groups) first- and second-order positions over time.

⁴ Following Section 2.2, it should be emphasised that these quick wins should not necessarily be regarded as normative endpoints of consensus. Rather, diverging perspectives can be just as valuable – albeit less instrumental – as conclusions of the dialogue meetings.

Step 3: Assess the extent to which participants were satisfied with the results of the dialogue meetings, and reflect on whether follow-up activities were initiated (ex post).

- In order to see whether participants were satisfied with the results of the meeting, and were intending to initiate or participate in follow-up activities, we analysed the evaluation forms they filled in directly after the meeting. In these forms they were asked to reflect on a number of aspects related to the structure of the meeting, their contributions, new insights they gained, the matches that were identified and their plans for future contact with other participants. These reflections provide a first idea on the extent to which participants were satisfied with, and feel committed to, the outcomes. About six months later we did a second evaluation round and interviewed several of the participants to see whether follow-up activities had already been initiated.

In Section 5 we present the results of the first two steps and in Section 6 the results of the third step.

5. Results: step 1 (ex ante) and step 2 (ex durante)

In presenting the results we distinguish between three groups of participants: ecogenomics researchers, user groups, and participants related to policy (for a specification of these participant groups for the two meetings, see Table 1 Section 4.1). Below we present the positions before and during the meeting on first- and second-order level, and characterise shifts in these positions, separately for the two dialogue meetings.

5.1. Dialogue: 'Ecogenomics in agriculture and nature conservation'

5.1.1. First-order level

In their presentations, researchers often talk in terms of 'screening', 'imaging', 'understanding', 'measuring' and 'predicting', while users emphasise the importance of providing advice for action/steering in order for them to be able to tackle practical problems. Policy participants stress the opportunities of ecogenomics for understanding the functioning of ecosystems, and related ecosystem services.⁵ In the following group discussions, these different starting points were discussed in depth.

An interesting observation is that users first stress that only measuring and detecting elements in the soil is not enough, but that it is important to accompany those measurements with advice for steering, i.e. to influence soil characteristics in desirable directions. In response, ecogenomics researchers emphasise that they are only beginning to understand the soil ecosystem, and that knowing how to intervene is currently a bridge too far. As the discussions go on, the users seem to adjust their expectations of ecogenomics, and

⁵ An Ecosystem Service is a public service provided by the soil ecosystem, as recognized by the user, government authorities and society. In the Netherlands a total of 10 Ecosystem Services have been defined in the categories of soil fertility, resistance to stress and adaptation, the soil as buffer and reactor and biodiversity (Rutgers et al., 2008).

Table 3
Matches and quick wins 'Ecogenomics in agriculture and nature conservation'.

Matches and quick wins	Elaboration	What is needed?
Ecogenomics and disease suppression	Test hypothesis related to disease suppression that is based on practical experiences ('farmer's knowledge') to see if a scientific base can be determined. Use ecogenomics as a monitoring tool.	Establish an interdisciplinary team in which the relevant scientific disciplines are represented and that includes practical oriented parties. This is crucial to translate between science and practice.
Ecogenomics and nutrient preserving capacity	Farmers are experimenting with their soils in order to optimise nutrient preserving capacity. Ecogenomics tools can be used in those situations and results can be linked to practical experiences.	Use the experimental attitude of farmers and link practical experiences with ecogenomics measurements.
Prioritising ecosystem services	Selection of ecosystem services that are linked to the biotic fraction of the soil, and where more insight is needed. Two important questions are: (1) What is societally relevant?, (2) What is scientifically interesting?	Conduct a needs assessment that includes different perspectives and input from practice.
Policy, rules and regulations	Ecogenomics should not try to change current rules and regulations. There are however areas in which regulation is still in development (i.e. for long-term monitoring, or with regard to understanding ecosystem services), and where ecogenomics could make a contribution.	Develop a shared language. Do not try to change current policies, but try to adjust to the practical context.

shift in the direction of the ecogenomics researchers: they start raising opportunities for ecogenomics related to understanding soil functions like 'soil health' and 'disease suppression'. They also come up with ideas to relate ecogenomics measurements to observations in practice and increase understanding of why certain interventions work out or not. As an example, the applied researchers that participated expect to gain quick results from testing hypothesis in practice. In response to these ideas, some ecogenomics researchers seem to make a shift toward the user groups. In thinking about how to proceed with ecogenomics in the future, they start including this user perspective. One of the ecogenomics researchers said that it would be valuable to meet with farmers, discuss their problems, and try to match ecogenomics data with their practical experiences.

The policy-related participants have a different focus than the users. They repeatedly stress current established policy directions, or emerging policy directions that need more scientific grounding. They have a more long-term focus than the users, and underline the potential of ecogenomics as a monitoring tool with the aim to understand ecosystem services. They seem to have a rather firm position and mainly try to convince researchers of linking up with initiatives already supported by, or set up within, the policy arena. Some ecogenomics researchers are attracted to the long-term monitoring focus of the policy participants. The four matches and quick wins that were identified and discussed during the last part of the meeting illustrate this division between a short-term-practical focus and a long-term-policy focus (Table 3). Two quick wins focused on practical field questions regarding disease suppression and nutrient preserving capacity, the other two focused on prioritising ecosystem services on which ecogenomics research should focus and on how ecogenomics fits in current policy, rules and regulations.

5.1.2. Second-order level

At the start of the meeting there was a similarity in second-order elements among the participant groups. Underlying assumptions, like sustainability, are shared by all the participants and are emphasised in the starting presentations. However, in the discussions these normative aspects receive little attention. One explanation might be that sustainability is perceived as a basic or ground value that is not under discussion. Another reason could be that the term 'sustainability' is rather abstract and broad. Next to sustainability, users stress the importance of practical usability and profitability, and policy-related participants mention economic utilisation of ecogenomics knowledge. Ecogenomics researchers emphasise the way in which they set up and perform their research. In reaction to comments made by user groups about the importance of linking the research to practical observations, they seem to

become aware of the basic assumptions underlying their research. Users indicated that the type of research currently conducted within the Ecogenomics Consortium is incompatible with their practical questions. As an example, one user stated that looking at one soil organism is a too narrow focus. He proposed to turn the research around, and start from a practical situation in which certain cultivation measures or additives are used to increase disease suppression. The question for ecogenomics researchers would be: do those actions actually have an effect? In response, some researchers explicitly stated that they would organise and set up their research in a completely different way in order to address those types of questions from practice.

On a second-order level, users seemed to be shifting in the direction of the researchers. First, they are underlying their demands by stressing profitability, practical usability and the value of experience. However, as the discussions go on, they start stressing more broad and long-term issues, like the importance of defining what a healthy soil is. They also question the basic assumptions of the researchers (do you look at correlations or causal relations? do we need to measure everything that is measurable? do we precisely need to know the mechanisms?). However, this might be more a language shift than a shift in basic values or assumptions. Their remarks are still clearly formulated from a practical perspective and aim to sharpen the views of the researchers.

Also on the second-order level policy-related participants seem to be rather isolated from the other participants. In addition to stressing the importance of economic utilisation, they stress the opportunities for ecogenomics to contribute to understanding the meaning of soil quality. To that aim, they believe a holistic approach is needed in which the interrelatedness of soil functions is a central element. Some ecogenomics researchers who are attracted to the policy-focus are shifting in their direction, and also start to mention aspects like interrelatedness.

5.1.3. Characterizing the shifts

In Table 4, the positions of the participant groups on a first- and second-order level before, and during the meeting, are summarised. At the beginning of the meeting there are differences in both first- and second-order positions of all participant groups: their demands are 'divergent'. During the meeting a shift can be observed on both first- and second-order positions of users in the direction of the ecogenomics researchers: they understand that ecogenomics research cannot yet specifically address their questions, and as a result think of relevant questions or approaches that can be addressed. In turn, some ecogenomics researchers (group 2) shift toward the users, they start to stress the importance of linking research with practice. Their demands are becoming more

Table 4
First- and second-order positions during the meeting 'Ecogenomics in agriculture and nature conservation'.

Participant group	Step 1 (ex ante)		Step 2 (ex durante)	
	1st order	2nd order	1st order	2nd order
Ecogenomics researcher	Measuring	Ecosystem health Sustainable soil use	Group 1: measuring and monitoring Group 2: linking research with practical observations Advice not yet achievable Need to link research with practical observations Monitoring	Scientific utilisation Societal utilisation Interrelatedness Practical usability, practical experience
Users	Need for advice/steering	Sustainable soil use Profitability		Practical usability Practical experience Scientific and practical sound research
Policy-related	Link up with established policy frameworks	Sustainable soil use Economical utilisation of knowledge		Sustainable soil use Interrelatedness Economical utilisation of knowledge

'complementary' or 'shared'. The same can be observed between policy-related participants and some ecogenomics researchers (group 1) when discussing the need for monitoring tools and approaches: they also shift toward each other on both first- and second-order elements. No shifts on both first- and second-order are observed between users and policy-related participants. This implicates that 'divergent' demands remain between users and policy-related participants.

5.2. Dialogue: 'Ecogenomics and soil pollution'

5.2.1. First-order level

In the soil pollution meeting, ecogenomics researchers focus on measuring and detecting in their presentations. In their research they assess the actual effects of pollution on the soil ecosystem health and, to some extent, on human health. An additional aspect that is emphasised in the presentations is to understand how bioremediation within soils (the potential of organisms, usually micro-organisms, to break down pollutants in soil) works, in order to develop mechanisms to enhance this soil function. User groups and policy-related participants have a different focus in their presentations. They indicate that currently, biological remediation comprises roughly 10% of all remediation projects (for the other 90% techniques like excavation and chemical remediation are used). Users stress that there is a need for more practical knowledge about biological remediation processes and the actual health risks of pollution in order to increase practical usage. On the other hand, policy-related participants emphasise the difficulty of introducing new tools in practice, in particular when it concerns biological measuring methods. As an example they stressed that it already takes more than 10 years to add three new chemical tests to the current list of pollutants.

In the discussions, policy-related participants try to convince the ecogenomics researchers of the practical limitations of introducing new tools, and the potential for long-term monitoring. For the ecogenomics researchers, this is challenging their initial ideas about developing new and better tools that might have the potential to replace existing tools that focus on chemicals. They repeatedly stress that current rules and regulations need to be reconsidered, and that their research can contribute to that. Policy-related participants advise ecogenomics researchers to link up with existing policy directions in which biological tools are used. For example, nematode analyses are already used to prioritise polluted sites that need to be cleaned. A policy-related participant emphasised the potential of ecogenomics to improve these tools. In response, an ecogenomics researcher indicated that within the Ecogenomics Consortium also new tools are being developed that might be better, but focus on a different organism. He pleads to reconsider current tools when better tools become available, even though it might trigger resistance from the perspective of current frameworks. This illustrates how ecogenomics researchers become aware of the difference between aiming for tool development that is most appropriate from a scientific point of view, or aiming for tool development that connects best with existing frameworks and has high potential to be implemented in practice.

During the discussions, both users and policy-related participants emphasise the importance of validation and translation of test results to risk assessments. Ecogenomics researchers stress that there is a great difference between describing effects, which is the focus within the research at this moment, and predicting risks. In response, both users and policy-related participants indicate that, in order for ecogenomics to become useful for practice, ecogenomics researchers need to think about how to scale their tools, and how to weigh the different tools that

Table 5
Matches and quick wins 'Ecogenomics and soil pollution'.

Matches and quick wins	Elaboration	What is needed?
Ecogenomics and TRIADE	TRIADE is a new soil risk-assessment framework that combines chemistry, biology and ecology. Ecogenomics could contribute valuable tools.	The Ecogenomics Consortium needs to focus on gaining confidence with the tools and on validation. Visibility is important: other parties have to know where to turn to for specific tools.
Ecogenomics and soil health	The definition of a 'healthy soil' is unclear. It is however important to define because it is the backbone of determining whether situations are acceptable or not.	This type of research fits in the current Ecogenomics Consortium. There needs to be a strong link with ecosystem services, in collaboration with the Ministry of Housing, Spatial Planning and the Environment (VROM).
Grey areas in rules and regulations	In some cases, a soil has elevated levels of pollution, but does not exceed the intervention levels. In cases of e.g. playgrounds or gardens, the question is whether this is worrisome. Are there health risks?	Look for 'problem owners' (e.g. municipalities), and start working on their soil samples.
Ecogenomics and the deep soil	Link ecogenomics research on the deep soil to current societal issues like heat-cold storage (HCS) and CO ₂ -storage.	Organise a pilot on HCS. First idea about the question that could be answered in this pilot: 'In case of HCS, how long does it take before there is a new stable situation in the deep soil, and how does that relate to a higher or lower bioremediation capacity?'.

Table 6
First- and second-order positions during the meeting 'Ecogenomics and soil pollution'.

Participant group	Step 1 (ex ante)		Step 2 (ex durante)	
	1st order	2nd order	1st order	2nd order
Ecogenomics researcher	Measure and detect	Ecosystem health Human health Sustainable soil use	If new tools are better: go for it From describing effects to predicting risks is difficult Visibility	Scientific utilisation versus societal utilisation
Users	Increase practical usage of bioremediation	Human health Security Safety Financial risks	Validate and scale the tools Look for problem owners	Societal utilisation Experience Confidence
Policy-related	Long-term monitoring of polluted areas New tools = mission impossible	Human health Economic value of soil (vital soil)	Link up with existing frameworks/initiatives Validate and scale the tools Look for problem owners	Societal utilisation Human health Economic value of soil (vital soil)

are being developed within the Ecogenomics Consortium against each other.

The participants together selected four matches and quick wins for further discussion (Table 5). Two of these clearly reflect the policy perspective (TRIAD and soil health), the other two focus on concrete cases (grey areas and heat-cold storage).

5.2.2. Second-order level

At the start of this meeting, there seems to be some overlap in second-order elements between the groups. Scientists emphasise sustainability and (ecosystem) health, whereas users and policy-related participants both stress human health as a crucial element when talking about soil pollution. For users human health implies the need of ensuring a high level of security when remediating pollution. Ensuring security has two main purposes: increasing safety and reducing financial risks. Policy-related participants emphasise that a focus on human safety is central to current policies relating to soil pollution. Furthermore, they stress that although ecological functions and ecosystem health is interesting, it is not yet economically valued. In that respect, a participant from a governmental advisory organisation expressed a desire to use ecogenomics to put soil in a different perspective and vocabulary: 'from dirty to vital'.

In emphasising the need for scaling and weighing of ecogenomics tools (see Section 5.2.1) users and policy-related participants use terms like 'confidence' and 'experience'. Experience with – and confidence in – the tools are needed for users to convincingly argue with the authorities their choice for using biological tools instead of chemical tools. Furthermore, experience with new tools is needed for users to minimise their financial risks. In discussing how to realise scaling and weighing of ecogenomics tools, ecogenomics researchers stressed the inherent difficulty of this type of validation in scientific research. Validation within science focuses on publications and patents, and does not guarantee translation of research results to practice. Both ecogenomics researchers and policy-related participants emphasise organisational and institutional challenges in translating from scientific utilisation to societal utilisation (as demanded by the other participants).

5.2.3. Characterising the shifts

In Table 6, the positions of the participant groups on a first- and second-order level before, and during the meeting, are summarised. At the beginning of the meeting there is a difference in first-order positions of three groups, while there seems to be agreement to some extent on the second-order level. Participants seem to agree on their underlying assumptions, but disagree on their first-order demands: their demands are 'untuned'. During the discussions, users and policy-related participants start raising more similar issues on a first-order level, their demands

are becoming more 'shared'. During the discussions, ecogenomics researchers do to some extent shift toward the other participants on a first-order level. They seem to understand the points raised by users and policy-related participants, but in response mainly challenge these ideas. The demands of ecogenomics researchers versus users and policy-related participants thus mainly seem to remain 'untuned'.

6. Results: step 3 (ex post)

In the previous section we focused on the dynamic interactions between participants during the meeting and the learning processes that took place. Here we reflect on the satisfaction of the participants with the results of the dialogue meetings, their intention to initiate or participate in follow-up activities, and the actual follow-up activities that were initiated up till 12 months after the dialogue meetings.

6.1. Evaluation directly after the meeting

With regard to the structure of the meeting, all participants experienced the meeting design as positive, and highly valued the time for discussion. They did, however, not agree about the relation between the diversity of participants and the quality of the discussion. Some of them remarked this diversity as a problem in the discussions, while others would have liked even more parties to be present.

Almost all participants reported that they had been able to contribute their ideas and that they gained new insights. Interestingly, some participants specifically mentioned their discovery of differences in 'language use'. With regard to the satisfaction about the matches, there is a difference between the two meetings. For the meeting on soil pollution, almost all participants were of the opinion that matches and ideas for practical realisations were identified. They stressed that follow-up on these matches would be needed, since the practical implementation had not yet been fully clear and elaborated on. In their evaluation form, several participants of this meeting indicated that they had already begun to make appointments to start joint projects on the identified matches. For the meeting on agriculture and nature conservation, the opinions on the identified matches were more diverse. Some participants indicated that the objective of the meeting was too ambitious and that more discussion was needed on what issues should be prioritised. Others indicated that the discussions were too much on a 'high level', while discussing connections between supply and demand could be much more concrete. Nevertheless, participants found that research, practice and policy came closer together, and that the matches functioned as a first step in that process.

6.2. Follow-up

The results of the evaluation that took place directly after the meeting indicated that – especially during the meeting on soil pollution – several concrete matches and quick wins were identified and that concrete appointments were made. In a period of six to twelve months after the dialogue meetings we conducted an evaluation round and interviewed the participants that had previously expressed interest in starting joint projects with the other participants. In addition, we screened new ecogenomics related project proposals. It was found that, except for one, the ‘quick win projects’ had not been started, discussed again or articulated. Does this imply that the dialogues had no actual impact? From the results of the evaluation there are indications of impacts of the dialogue meetings on three levels: (1) at the individual level of the ecogenomics researchers, (2) at the program level of the Ecogenomics Consortium, and (3) at a cross-institutional level.

First, we noticed that after the meetings several ecogenomics researchers personally started rethinking their research approach and the aims and objectives of their projects. One researcher expressed that – because of the dialogue – he had become aware that a lack of willingness ‘to give up a winning horse’ (or in this case a winning invertebrate, his department’s pet model organism) could cause his research to become socially less relevant, as policy-relevant tools are currently often based on another organism (see discussion in Section 5.2.1). He also learned that it is important to link up his data with potential human health risks. In order to increase the societal relevance of his research, he expressed several new ideas for a research agenda. One example is that he considered starting to search for a ‘universal stress transcriptome’: a strategy to translate model organism stress responses (to environmental stressors) to indications of potential human health risks. Another ecogenomics partner, who prior to the meeting desired a radical change in current policy practices for soil pollution, a few months after the meeting indicated that he was reconsidering his strategy. He realised that a focus on biological effects of pollution would currently be a bridge too far, as governmental rules and regulations have a strong focus on measuring concentrations of pollutants. Now he thought about tapping-in to current practices so that people first get confidence in biology-based approaches. He explained that he became aware of the fact that stakeholders, like companies that are confronted with remediation, would probably not be in favour of immediate and dramatic scale and rule changes. Reconsidering the way they set up their research, and revising their strategies with regard to addressing needs from policy and practice, are indications that the interactions during the dialogue meetings actually induced changes within the Ecogenomics Consortium.

Second, on a program level, the Ecogenomics Consortium mainly took up the policy-related results from the dialogue meetings. The progress reports and the documents and plans for a follow-up of the Ecogenomics Consortium and another joint ecogenomics initiative contained concrete references to ‘ecosystem services’. In one of the proposals for a follow up initiative this topic even became one of main themes. One explanation is that the Ecogenomics Consortium currently has a strong focus on the realisation of a new ecogenomics program for which governmental funding is needed. In that respect, the Ecogenomics Consortium feels a need to link up with existing and emerging policy frameworks, and as a result started to use the term ‘ecosystem services’ in the new proposal. This rhetoric shift illustrates one clear advantage of the dialogue meetings for the Ecogenomics Consortium: it provides insight in relevant buzz-words and offers ecogenomics researchers the possibility to position themselves better. In addition, the changes that were observed on the individual level of the ecogenomics researchers were traceable in specific research projects that were designed as

part of this proposal (e.g. references were made to human health risks).

Third, one of the ‘quick wins’ that were formulated in the meeting on soil pollution was realised partly outside the Ecogenomics Consortium. A collaboration of several companies, local and national government, and research institutes initiated and funded an innovative project on the potential of heath-cold storage, and the effects on soils. Some of the partners of this new initiative also attended the dialogue meeting. Although partners of the Ecogenomics Consortium were enthusiastic about this quick win, only one participating company joined this new initiative.

7. Discussion

This paper aims to address the current lack of attention for multi-stakeholder learning in large scale research collaborations, by reflecting on a methodological approach developed within the framework of a Dutch public–private research consortium. The dialogue meetings, as sites of interaction, aimed to facilitate learning between ecogenomics researchers, end-users and other relevant stakeholders. This learning could then lead to joint identification of (mis)matches between research and (policy and user) practice, and the articulation of ways to realise the matches and overcome potential obstacles. Following this, two main lines were taken up in this paper: (1) explicating a methodological approach to organising user–producer interaction within the context of large public–private research collaborations, and (2) analyse to what extent learning and action are facilitated in the context of these collaborations.

7.1. Methodological and analytical approach

In this paper we presented a methodological approach for conducting multi-stakeholder dialogues within large research collaborations, and an analytical framework to analyse the learning it facilitated between participants. Clearly, putting a broad range of stakeholders together in a meeting does not automatically lead to a dialogue. Where differences in perspectives, interests and background are considered as valuable input, at the same time these differences make it difficult to achieve an open dialogue (Cuppen et al., 2009). Several participatory methodologies have been developed that (to a differing extent) provide tools and techniques to facilitate multi-stakeholder interaction (see e.g. Van Asselt and Rijkens-Klomp, 2002). However, despite a perceived need to broaden scientific inquiry by incorporating the perspectives of a broad range of stakeholders, the theoretical and methodological framework for science-based stakeholder dialogues remains underdeveloped (Welp et al., 2006). In addition, there lies a challenge in designing and evaluating methodologies that facilitate learning (Cuppen, 2010). Within the research described in this paper we took up these challenges and aimed to make both a methodological and analytical contribution.

The methodological design of the dialogue meetings focused on the formulation of promising matches between supply and demand, and related short-term actions (quick wins). In both meetings, participants jointly succeeded in the identification and formulation of matches and quick wins. For some, participants agreed on their relevance, indicated a need for follow-up initiatives, and in some cases even made concrete appointments. On other matches and quick wins, there was less agreement, and participants indicated a need for further discussion. In those cases, discussing the matches illustrated potential practical opportunities for ecogenomics, and inspired participants to further discuss the topic. These observations illustrate the two functions of identifying matches and quick wins as a central methodological step

in the dialogues. First, it leads to the joint identification of innovative opportunities for ecogenomics, and serves as a step in research agenda setting. Second, the matches and quick wins illustrate the creative potential of the participants when joining their knowledge, ideas and perspectives. As such, the experience serves as a ‘probe’; while constructing matches participants learn that creative new ideas can be the result of these multi-stakeholder interactions. This is in line with what Hyysalo (2009 p. 730) claims about learning on a micro-level: “learning in network collaboration among developers and users is preceded and accompanied by learning for this collaboration”.

Nevertheless, observing learning processes, and actually ‘measuring’ whether learning took place during the dialogues is difficult, as it involves cognitive processes and actions of individuals (Schön, 1983; Schön and Rein, 1994). Looking at first- and second-order learning within a dialogue setting is indicative for the extent to which participants understand each other and actually have a ‘genuine dialogue’, but says little about the extent to which the knowledge that is developed is anchored in the thinking and doing of actors. Furthermore, it is questionable whether second-order learning can be achieved in one meeting. For second-order learning, an atmosphere of trust and a commitment to reciprocity is essential (Grin and Hoppe, 1995). Although the dialogue meetings aimed to provide for these conditions, it could be argued that for the building of trust, and for learning to be digested, more rounds of interaction are needed (Bhola, 2000; Welp et al., 2006). Also to further specify and concretise the matches that were identified in the dialogues on ecogenomics, it would be sensible to organise and facilitate follow-up initiatives.

7.2. From learning to acting

The second objective in this paper, analysing to what extent learning and action is facilitated in the context of the dialogue meetings, is discussed by first focusing on the micro-level learning processes, and subsequently on the longer-term effects of this learning.

7.2.1. Shift from initial positions to final positions

In the dialogue meetings three types of stakeholders participated who articulated their views and through interactions learnt from the perspectives of others to differing degrees. In this paper we showed the learning that occurred on a first- and second-order level, and how the positions of the participants in both dialogue meetings changed to some extent. In the dialogue meeting on agriculture and nature conservation, the positions of users and ecogenomics researchers shifted from ‘divergent’ to ‘shared’. The analysis of the dialogue meeting on soil pollution shows how the positions largely remained ‘untuned’. To summarise, *ecogenomics researchers* gained insight in the needs from practice and policy, and were challenged to reflect on their own research from a different perspective. *Users* became aware of the potential of ecogenomics, and at some points had to adjust their expectations, e.g. on the possibility for influencing research and development. They proved to be capable of an in-depth discussion of technical aspects of ecogenomics, and challenged the ecogenomics researchers to translate the research to their practices. Interestingly, with regard to positions of the *policy-related participants* broadly three types of roles can be observed who have distinct styles of reasoning.

First, the government acts as a problem owner in case of soil pollution. As land owners, national and local authorities have an interest in reducing human and environmental risks of soil pollution. In their role of problem owner, there is a focus on short-term opportunities for matching ecogenomics tools with practical needs. This perspective is closely related to the user-perspective that can be observed in both dialogue meetings. Second, the government

acts as a regulator to guide behaviour in the fields of soil pollution, agriculture and nature conservation toward what is socially desirable. In the role of regulator, emphasis is put on the established policy frameworks and the rigidity of these frameworks. As an example, ecogenomics researchers who propose to change current rules and regulations by developing better tools are strongly discouraged to do so. Third, the government acts as a stimulator of innovation by funding public–private research initiatives, such as the Ecogenomics Consortium. In the role of stimulator of innovation, they use broad and abstract rhetorics, and refer to e.g. ‘ecosystem services’, ‘putting soil in a different perspective’, and ‘long-term monitoring’. In the contributions of policy-related participants, the roles of regulator and stimulator of innovation are dominant. Interestingly, in the discussion there seems to be little room for manoeuvre in their positions. They mainly stick to their initial ideas and do not seem susceptible to the ideas raised by other participants.

One explanation for this limited room for manoeuvring is that, in the case of ecogenomics, the dialogues were not initiated by the government, and policy-related participants might not feel a direct need to inform the policy process with the dialogue results. The aim of the dialogues was also not directed at influencing the policy making process, but at *shaping the research agenda*. Nevertheless, the involvement of the policy arena in dialogues that are initiated by a public–private research consortium is crucial, as the policy processes have direct influence on the direction and form of innovation. At the same time, the government has an important stake as potential future user of ecogenomics tools, and as stimulator of innovation. The input of the policy-related participants we observed during the dialogues on ecogenomics raises a question: what scope can there be for dialogue when the (policy) direction is already set (Irwin, 2006 p. 316)? Therefore, *shaping the policy agenda* as an additional objective would be relevant for these types of stakeholder dialogues. We would suggest that, in addition to creating commitment of the researchers, the design of a dialogue process needs to create a sense of ownership and commitment for its shape and direction among policy-related participants as well. This is challenging, considering the compatibility of dialogue processes with established modes of policy making (Hagendijk and Irwin, 2006). Keeping dialogue processes at arm’s length from formal decision making gives governments the opportunity to postpone their judgement and respond to the results till after the process, to keep room for manoeuvring. A government taking such a position in user–producer interaction in an early stage of S&T innovation, potentially hampers the follow-up on innovative outcomes. We would argue that these types of roles of governments are likely to coincide, and potentially conflict, in other cases of emerging technologies and public–private research collaboration as well.

7.2.2. Longer-term learning effects

During the dialogues, the focus was on the first two learning stages (as described in Section 2.3): understanding the problem and devising a plan. The identification of matches between research and practice, and the formulation of short-term actions, aimed to initiate the subsequent learning stages: executing the plan and reflection. Within the dialogue meetings, a space was created in which the participants were challenged to critically reflect on their own and each others’ perspectives regarding ecogenomics developments. From the analysis of the results it becomes clear that learning between participants occurred to some extent on both first- and second-order levels. This learning implies that the dialogue meetings facilitated a ‘reflexive discourse’ (Genus, 2006, Genus and Coles, 2005; Jelsma, 2001) Based on the results of the ex-post analysis (see Section 6.2), there are indications that learning facilitated during the dialogues had a longer-term effect on

three levels (the individual level of the ecogenomics researchers, the program level of the Ecogenomics Consortium, and the cross-institutional level). Concrete topics that were discussed during the dialogues could be traced back in the thinking and acting of ecogenomics researchers, and in new ecogenomics initiatives and project proposals.

At the same time, these longer-term effects only partly reflect the learning that took place during the dialogue meetings. The limited number of follow-up initiatives, and the absence of effects on the research projects of the Ecogenomics Consortium, illustrates the difficulty of translating the learning that took place during the dialogue meetings into 'real-time' actions. But to what extent is this difficulty a general one, i.e. are there comparable experiences in other multi-stakeholder processes for research agenda setting? There are a number of examples on research priority setting in healthcare that are illustrative for how end-users (in these cases often patients) can make valuable contributions to research agenda-setting, and, as such, enhance the relevance and quality of health research (Broerse et al., 2010a,b; Caron-Flinterman et al., 2006; Mitton et al., 2009). However, comparing these processes to the dialogues described in this paper shows considerable differences in context and aims. In example, multi-stakeholder interactions in health research are often initiated by research funding agencies, who specifically search for broadly informed prioritisation of research topics. These prioritisations are subsequently used to guide decision-making on research funding. With the dialogues, the Ecogenomics Consortium was not seeking to redefine its research agenda. There was also not a direct need to do so, as the research that is being conducted within the Ecogenomics Consortium already received funding, and there was no room to change projects or start new ones.

Although little has been published on stakeholder participation in large research collaborations working on emerging technologies, a comparable process in the field of nanotechnology supports the results presented in this paper. In that process, also a discrepancy was observed in enthusiasm and plans developed during the multi-stakeholder interactions, and the longer-term effects (Merkerk and Smits, 2008). Clearly there are barriers that hamper translation of the results beyond the protected space of a dialogue. When stepping out of the dialogue setting into the real world, other dynamics, i.e. those related to traditional power relationships and institutional and funding structures, come into play which change the way dialogue outcomes are perceived and acted upon (Kloet et al., *accepted pending revisions*). The results of both processes point to the importance of studies that focus on these dynamics. At the same time, structured reflection on the methodological approach and the results of these types of processes is important to expose lessons for other practitioners in the field, and to gain insight in how to cope with constraining system dynamics.

8. Conclusions

Public–private research consortia increasingly have to deal with a heterogeneous stakeholder network. In order for research consortia to develop technologies that meet societal needs, the different ideas, preferences and positions of these stakeholders need to be addressed. This paper illustrates how stakeholders in various forms, such as users of new technologies and actors related to policymaking, can be involved in discussions with scientists about desirable directions for science and technology development in the context of public–private consortia. Multi-stakeholder dialogues are an effective way to achieve learning among and between participants, create matches and identify obstacles to innovation. The interaction offers direct benefits to the technology development process by exposing stakeholder needs and potential barriers regarding the

implementation of technologies in practice. Furthermore, involving a broad range of stakeholders increases the visibility of research consortia in related areas of application.

This study on multi-stakeholder dialogues within large research programmes forms a valuable contribution to existing literature on user involvement (Smits and Boon, 2008; Von Hippel, 1988), because it shows the micro-level dynamics of interactions between users and producers. It also provides a methodological contribution by illuminating the methodological and analytical steps, and unravelling the learning that takes place between participants of the dialogue meetings on first- and second-order level. As such, this study shows how a well-prepared dialogue, with a specific focus on learning between stakeholders, has the potential to bridge between research and practice. Nevertheless, organising learning processes that lead to sustainable long-term matches between science and practice is both difficult to achieve and to measure.

The research presented in this paper points to some challenges that need to be addressed. The involvement and role of policy-related participants in dialogue processes needs further elaboration, more specifically the question of how to develop a mutually beneficial relationship between dialogue processes and policy-making processes. Furthermore, translating the results beyond the protected space of the dialogue appears to be difficult. This indicates a need to further investigate how these types of interactive processes relate to the dynamics of the larger research system.

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